# Chandrayaan-3 Lander Module Assembly, Integration and Testing

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***Abstract*—The Chandrayaan-3 Lander involves significant complexities due to the dense packing of electronic systems, including power systems, Lander electronics packages, radio frequency systems, sensors and actuators. This paper addresses challenges in system-level integration and extensive testing needed for timely spacecraft realization. It details the electrical integration team's key activities, such as layout studies, electrical distribution design, fabrication, testing and grounding implementation. Additionally, it outlines the development and execution of complex test plans carried out in cleanroom, environmental test facilities, during composite module assembly and in launch pad to ensure that the spacecraft meets all operational requirements for orbit.**

***Index Terms*—Electrical distribution, Quality assurance, Composite module assembly, Launch campaign, Harness, Grounding, Assembly, Integration, Testing.**

## I. Introduction

The structure of Chandrayaan-3 Lander derives heritage from Chandrayaan-2 Lander which is modified I-1K structure. The Lander has a trapezoidal structure, as shown in Fig. 1. The overall size of the trapezoid is 2000 mm (Y) x 2000 mm (P) x 1166 mm (R). The primary structure is made of thrust cylinder and honeycomb panels with aluminum face skins. The central thrust cylinder & six shear webs make the primary structure of the Lander which is the main load bearing member. The secondary structure of Lander is made of vertical panels and mounting brackets for sensors, subsystems and antennas [1]. Two propellant tanks of capacity 470 L are housed inside the cylinder. The structure along with six shear webs and vertical panels accommodate sensors, subsystems, propulsion and thermal elements. The –Yaw inclined shear webs provide the required interface for the hold-down of Rover deployment panel. The +Yaw shear webs accommodate two presurant tanks, of 67L capacity each. Electronic packages are mounted on the other two shear webs –ve Pitch & +ve Pitch as well as on the inside face of top deck. The bottom deck of Lander provides interfaces for all the propulsion elements. Four 800 N liquid engines and eight numbers of 58N thrusters are mounted on the outside of bottom deck. Four landing legs are also mounted at the Bottom deck corner location. The propulsion elements are mounted on bottom deck with thrusters and liquid engines on the outside face. The vertical panel of Lander on –ve yaw

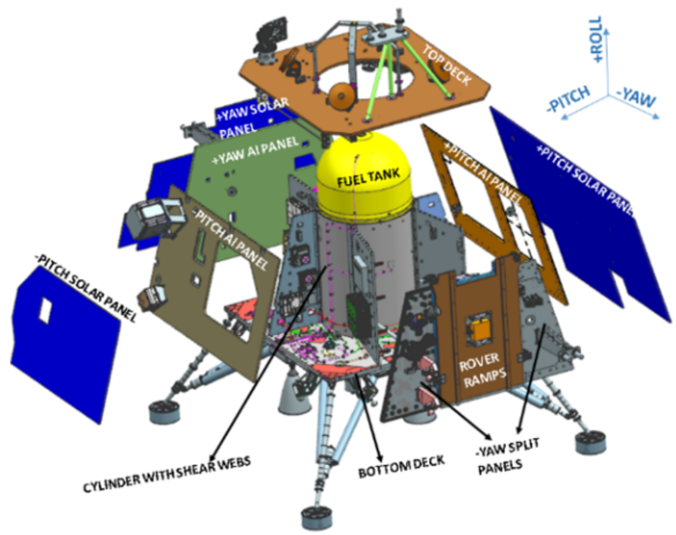


Fig. 1. Exploded view of Chandrayaan-3 Lander

side is made into two halves to take care of Rover deployment panel. The +Yaw panel is also a vertical panel accommodating sensors and Payload along with body mounted solar panel. The other two vertical panels (+Pitch and –Pitch) of Lander are mounted in an inclined manner and have body mounted solar panels on both. [1]. Since in lander all the packages are mounted onto the structure all their accommodation , interfaces and integration of newly realized packages like Throttleable Engine Control Electronics(TECEM) , Lander Doppler Velocity(LDV) sensor and Lander hazard detection camera needs a new sequence of test procedures.Hence their electrical integration plays a major role in ensuring the motto of total quality and zero deffect.

## II. CHANDRAYAAN-3 LANDER ELECTRICAL INTEGRATION ACTIVITIES

The electrical integration activities can be majorly classified as Electrical Distribution System (EDS) design, fabrication & testing; Grounding Implementation; Subsystem Assembly; Integrated Satellite Test(IST); Electromagnetic Interference (EMI) & Electromagnetic Compatibility (EMC)Tests; Environmental Test; Launch pad activities.

### *A. Electrical Distribution System Design , Fabrication & Testing*

EDS is a critical element in the spacecraft design. The design goes through lot of iterations to minimize the EDS mass by means of optimizing the harness length, routing corridor, inter-panel connectors etc. It is essential to realize a highly reliable EDS to meet the overall reliability goal of the spacecraft [2].

Chandrayaan-3 Lander Spacecraft harness interconnecting various subsystems can be broadly classified as Power distribution harness, Signal harness, Radio Frequency (RF) harness and MIL-STD-1553 Bus harness. However, each category of signals is again segregated into different groups based on the configuration and their functionality. [3]. An important aspect

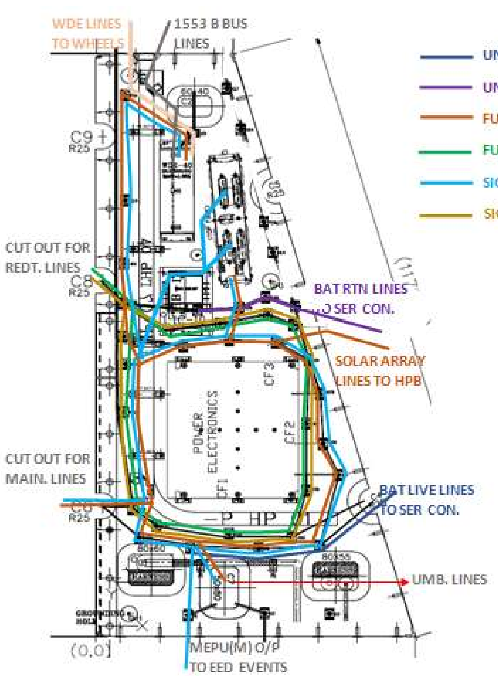


Fig. 2. -Pitch shear web harness routing

of EDS assurance is harness segregation, bundling, bunching and routing based on the characteristic of the electrical signals, built-in redundancy of systems and configuration requirements of spacecrafts. Chandrayaan-3 Lander Spacecraft harness is segregated into six categories in view of separating unfused live & return lines, main-redundant separation, power-signal separation . The routing of various bundles is shown in Fig. 2 for –pitch shear web of Lander. Raised betas which provide multi-level anchoring points vertically are used wherever possible to segregate the harness bundles in the same corridors. Lander EDS Design Fabrication conforms to ISO 9001- 2015(E). Fabricated harness is then validated for its performance during the integration phase of the spacecraft. Quality Inspection is carried out to assert that the final implementation of EDS meets the routing, bundling and bunching requirements.

### *B. Grounding Implementation*

Chandrayaan-3 Lander adopts Distributed single point grounding (DSPG) as it combines features of both single point and multiple-point grounding scheme [4]. To implement DSPG in Chandrayaan-3 Lander all bus returns of subsystem are taken back to the Power system through harness, secondary returns are the sub-star inside the package and referred to spacecraft structure at only one point. The spacecraft power ground is referenced to the structure at a single point only near to the Power Distribution package with resistance less than 2.5m$\Omega$. All packages and panels in Lander module also have bonding resistance w.r.t structure less than 10m$\Omega$, which is achieved by mechanical mounting and wired connections to structure. Fault current test for Lander module is done , where faulty current upto 10A is made to flow through structure to verify or validate the grounding scheme.

### *C. Subsystems Assembly, Interface and Functional Testing*

Power Subsystems along with Lander Electronics Package (LEP) and Navigation Guidance Control Electronics package (NGCE) are the first packages to be assembled and tested. These are followed by different sensors, actuators and then

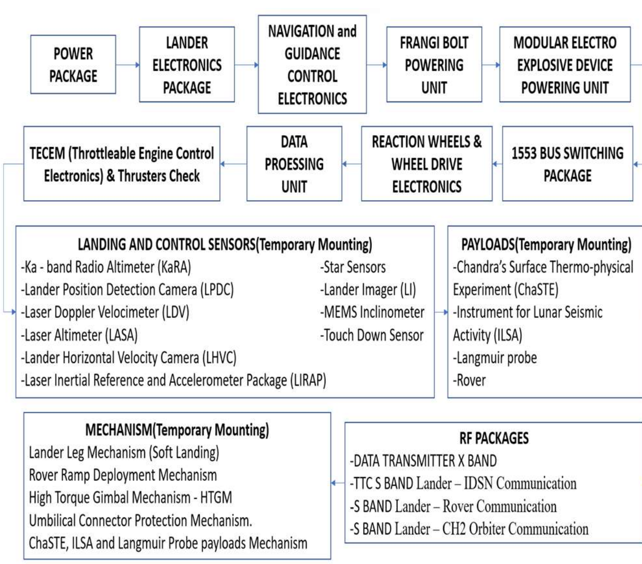


Fig. 3. Sequence of Subsystem Integration

by Telemetry and Telecommand (TTC), RF packages along

with various DC/DC converter packages are integrated. All the remaining mainframe packages along with base band data handling systems and the data transmitter are integrated. Finally, the payload elements are integrated and the payload chain performance in integration mode is evaluated. The detailed sequence of subsystem integration onto the lander structure is shown in Fig. 3.

*D. Integrated Satellite Tests*

The system level testing of a spacecraft is generally carried off in two phases which are dis assembled mode IST and assembled mode IST.

In dis assembled mode IST all the vertical panels, bottom deck and top deck which are being separately tested are all connected together through patch cables and a detailed check of all the subsystem testing is carried out. Since all the packages in lander are mounted on the structure, the subsystem test itself is considered as dissembled mode IST, no separate phase is again done for Chandrayaan-3 Lander. In Assembled mode IST all the vertical panels are assembled with structure and all interconnections are made. Detailed and necessary subsystem testing are carried out to ensure the integrity of the spacecraft prior to carrying out the actual Integrated Satellite Tests (IST). During assembled mode IST, the Spacecraft is powered through solar bypass harness and umbilical's, the subsystems performance is verified in the actual on-orbit configuration [5]. The sequence of tests carried out during Assembled mode IST is show in Fig. 4.

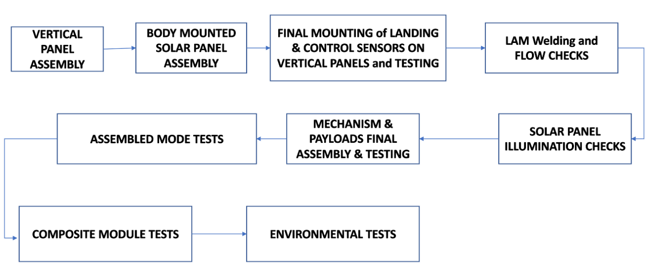


Fig. 4. Sequence of Assembled mode IST

Later Rover is mounted on Lander with three hold downs. Hold downs are designed to deploy the Rover Post successful landing. Fig. 5 shows Rover mounted on Rover Ramp of Lander. Lander to Rover electrical interfaces are established such that it did not interfere with Rover mobility. All electrical interfaces between Lander-Rover are routed through contacts present in these hold downs. Rover ON, Rover OFF, serial data interface for command transfer (clock, data and lock) and Rover bus voltage monitoring lines are the interfaces between Lander and Rover [5].

*E. Electromagnetic Interference (EMI) & Electromagnetic Compatibility (EMC)Tests*

EMI/EMC requirement for CH-3 Missions were taken care by doing the tests at subsystem level and system level.To

Fig. 5. Rover Mounted on Lander

carry out the EMI/EMC test the Lander module is moved to anechoic chamber and test setup is made as show in Fig. 6. To measure Radiated emissions and verify compatibility with GSLV Mk-III M4 [6] launcher compatibility tests are carried out , also to verify the polarization of all transmitting and receiving antennae polarization tests are done. The Standalone Auto Compatibility test for Lander is carried out by simulating the pre-landing, landing and post landing configurations of lander in Radiated mode. All the results were satisfactory and any deviation seen were taken care by implementing mitigation techniques like copper tapping the leaky connectors or implementing bronze mesh for sensitive receivers at system level.

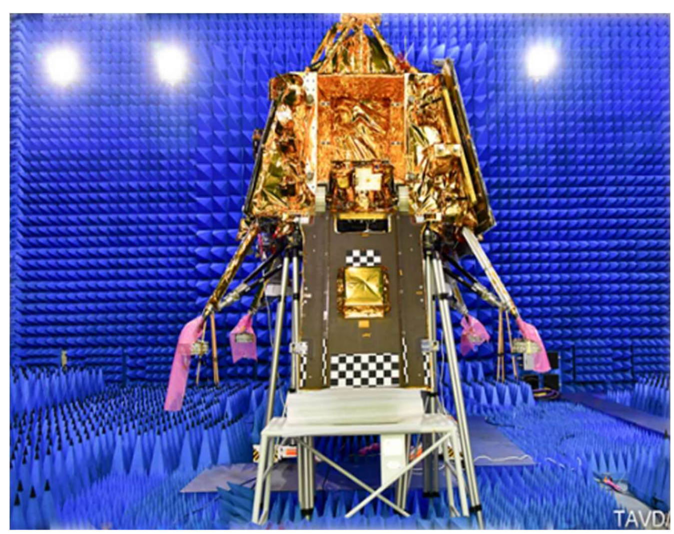

Fig. 6. Lander EMI/EMC Test

### *F. Environmental Tests*

Simulating the environmental conditions that are likely to be encountered by a spacecraft & its subsystem, components on land, launch pad and during orbiting in space is very essential to test the spacecraft performance in those extreme conditions and to ensure its safety. These tests are conducted

Fig. 7. Lander in Thermovac Chamber

as part of design validation, qualification and acceptance test levels, there by ensuring reliable performance of the spacecrafts in space. Environments experienced by spacecraft during launch are typically Vibration and Acoustic loads and in space are extreme cold and hot cycles [7] . Performance checks of the Chandrayaan-3 Lander Module Spacecraft Bus Systems for Thermal Vacuum conditions are carried out in Thermovac chamber as shown in Fig. 7. Further Dynamic tests (Vibration and Acoustics) are done in composite mode along with propulsion module in their respective facilities, simulating loads experienced by the composite module during launch [8].

### *G. Launch Pad Activities*

Lander is separated from Propulsion Module for completing Post Dynamic Integrated spacecraft tests. After that both Lander and Propulsion Module are transported separately to launch port, Satish Dhawan Space Centre (SDSC), Sriharokota (SHAR). Fuel filling activities for Lander and Propulsion Module are completed separately [9]. Separation system is installed on mechanical assembly Inter Module adapter (IMA) cone for Lander separation and then final assembly of Lander over Propulsion Module is completed as shown in Fig. 8. Integrated Module is mounted on Launch vehicle adaptor, both umbilicals are mated and space craft is cleared for further combined activities with Launch vehicle team.

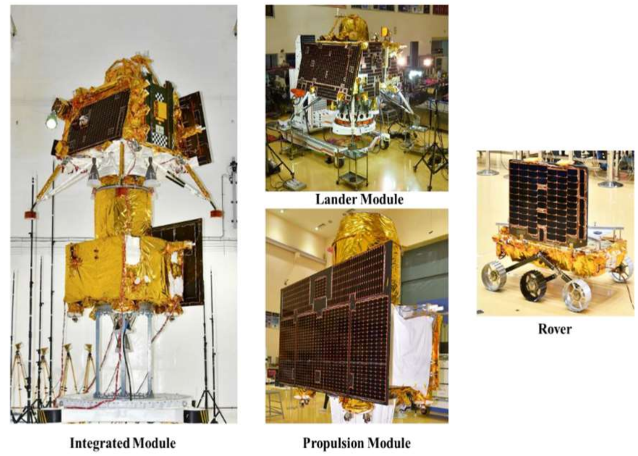


Fig. 8. Composite Module at Launch Pad

## III. CONCLUSIONS

Lander spacecraft is very complex as all the packages in it are closely packed on to the structure, hence their electrical integration plays a major role in ensuring systematic Quality assurance at all stages starting from Harness design fabrication& testing, system level tests & launch pad activities. The total mass of lander achieved was 1752.8 kg including Rover of 26.5 kg . The flawless on orbit performance of spacecraft resulting in successful safe and soft landing itself validates integration efforts in realizing such a complex system.

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